SNS COLLEGE OF TECHNOLOGY
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DEPARTMENT OF FOOD TECHNOLOGY

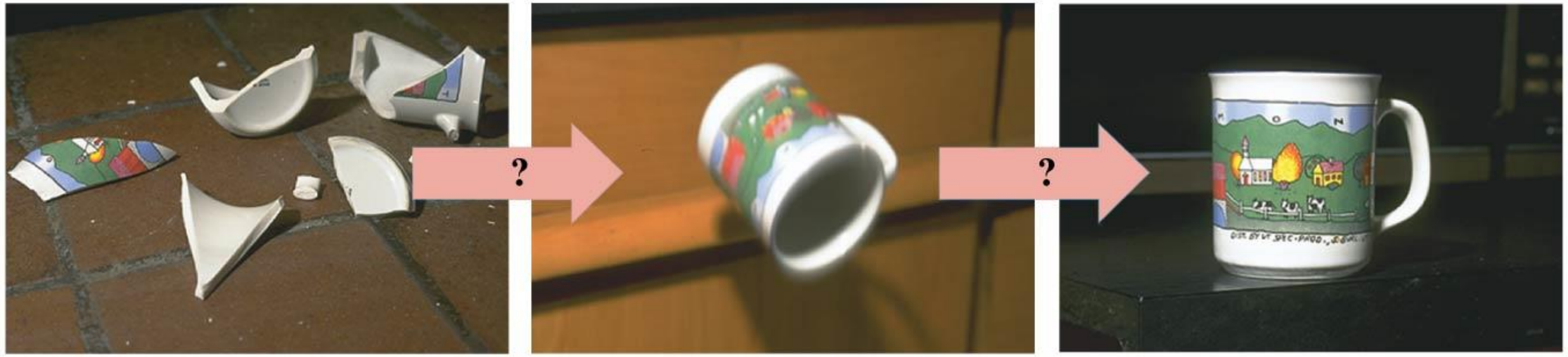
COURSE CODE & NAME: 19FTT301 & Refrigeration & Cold Chain Management

III YEAR / V SEMESTER

UNIT : I INTRODUCTION TO REFRIGERATION

TOPIC 3 : Second law of thermodynamics & its interpretation

The Second Law of Thermodynamics – Introduction



(a) Initial state.

(b) Later: cup reassembles and rises up.

(c) Later still: cup lands on table.

The absence of the process illustrated above indicates that conservation of energy is not the whole story. If it were, movies run backwards would look perfectly normal to us!

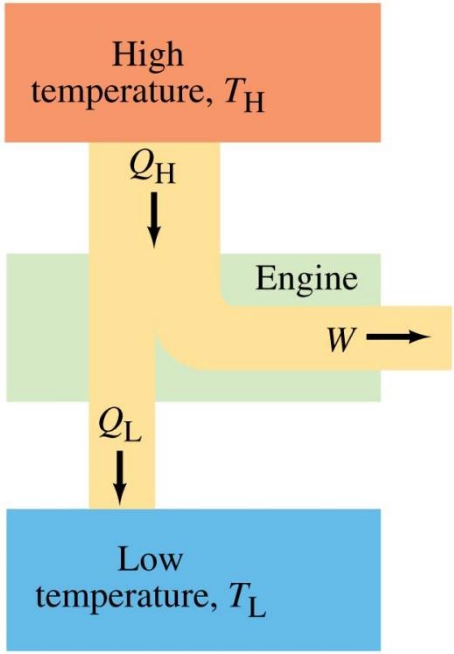
The second law of thermodynamics is a statement about which processes occur and which do not. There are many ways to state the second law; here is one:

Heat can flow spontaneously from a hot object to a cold object; it will not flow spontaneously from a cold object to a hot object.

Heat Engines

It is easy to produce thermal energy using work, but how does one produce work using thermal energy?

This is a heat engine; mechanical energy can be obtained from thermal energy only when heat can flow from a higher temperature to a lower temperature.



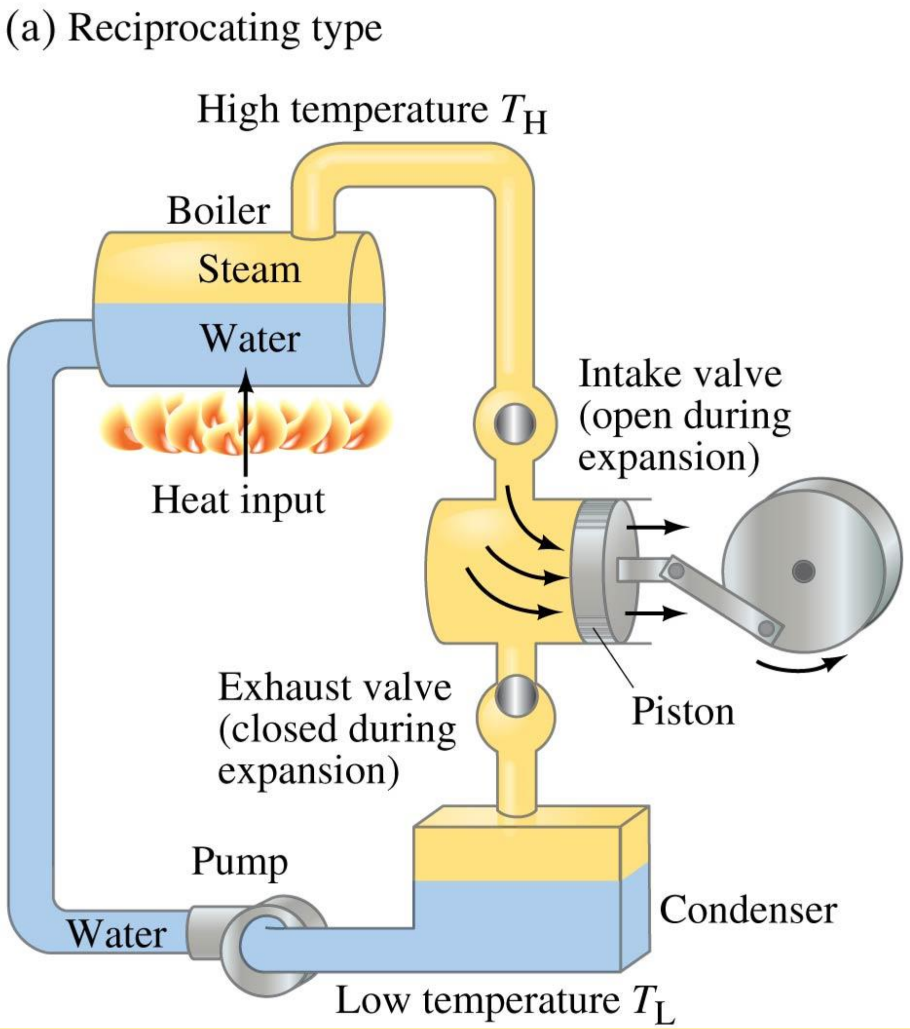
Heat Engines

We will discuss only engines that run in a repeating cycle; the change in internal energy over a cycle is zero, as the system returns to its initial state.

The high temperature reservoir transfers an amount of heat Q_H to the engine, where part of it is transformed into work W and the rest, Q_L, is exhausted to the lower temperature reservoir. Note that all three of these quantities are positive.

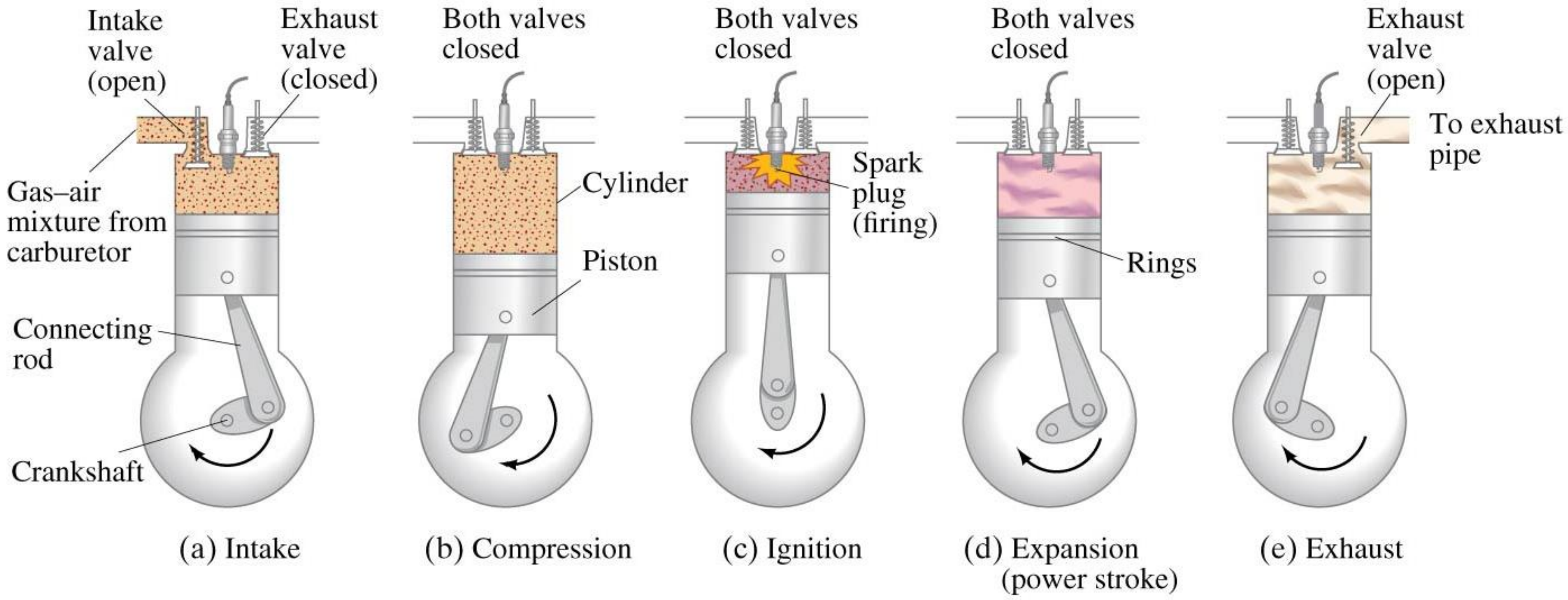
Heat Engines

A steam engine is one type of heat engine.



Heat Engines

The internal combustion engine is a type of heat engine as well.



Heat Engines

Why does a heat engine need a temperature difference?

Otherwise the work done on the system in one part of the cycle will be equal to the work done by the system in another part, and the net work will be zero.

The efficiency of the heat engine is the ratio of the work done to the heat input:

$$e = \frac{W}{Q_H}. \quad (15\text{-}4a)$$

Using conservation of energy to eliminate *W*, we find:

$$e = \frac{W}{Q_H} = \frac{Q_H - Q_L}{Q_H}$$

or

$$e = 1 - \frac{Q_L}{Q_H}. \quad (15\text{-}4b)$$

Entropy and the Second Law of Thermodynamics

Definition of the change in entropy S when an amount of heat Q is added:

$$\Delta S = \frac{Q}{T}, \quad (15\text{-}8)$$

Another statement of the second law of thermodynamics:

The total entropy of an isolated system never decreases.

Entropy is a measure of the disorder of a system.
This gives us yet another statement of the second law:

Natural processes tend to move toward a state of greater disorder.

Example: If you put milk and sugar in your coffee and stir it, you wind up with coffee that is uniformly milky and sweet. No amount of stirring will get the milk and sugar to come back out of solution.

Statistical Interpretation of Entropy and the Second Law

A macrostate of a system is specified by giving its macroscopic properties—temperature, pressure, and so on.

A microstate of a system describes the position and velocity of every particle.

For every macrostate, there are one or more microstates.

A simple example: tossing four coins. The macrostates describe how many heads and tails there are; the microstates list the different ways of achieving that macrostate.

Macrostate	Possible Microstates (H = heads, T = tails)	Number of Microstates
4 heads	H H H H	1
3 heads, 1 tail	H H H T, H H T H, H T H H, T H H H	4
2 heads, 2 tails	H H T T, H T H T, T H H T, H T T H, T H T H, T T H H	6
1 head, 3 tails	T T T H, T T H T, T H T T, H T T T	4
4 tails	T T T T	1

We assume that each microstate is equally probable; the probability of each macrostate then depends on how many microstates are in it.

The number of microstates quickly becomes very large if we have even 100 coins instead of four; the table on the next slide lists some macrostates, how many microstates they have, and the relative probability that each macrostate will occur. Note that the probability of getting fewer than 20 heads or tails is extremely small.

TABLE 15–3 Probabilities of Various Macrostates for 100 Coin Tosses

Macrostate		Number of Microstates	Probability
Heads	Tails		
100	0	1	7.9×10^{-31}
99	1	1.0×10^{2}	7.9×10^{-29}
90	10	1.7×10^{13}	1.4×10^{-17}
80	20	5.4×10^{20}	4.2×10^{-10}
60	40	1.4×10^{28}	0.011
55	45	6.1×10^{28}	0.047
50	50	1.0×10^{29}	0.077
45	55	6.1×10^{28}	0.047
40	60	1.4×10^{28}	0.011
20	80	5.4×10^{20}	4.2×10^{-10}
10	90	1.7×10^{13}	1.4×10^{-17}
1	99	1.0×10^{2}	7.9×10^{-29}
0	100	1	7.9×10^{-31}

Now we can say that the second law does not forbid certain processes; all microstates are equally likely. However, some of them have an extraordinarily low probability of occurring—a lake freezing on a hot summer day, broken crockery re-assembling itself; all the air in a room moving into a single corner.

Remember how low some probabilities got just in going from four coins to 100—if we are dealing with many moles of material, they can become so rare as to be effectively impossible.

THANK YOU...